Harvard Forest Summer Research Program In Ecology

23rd Annual Student Symposium

August 6, 2015

23rd Annual Harvard Forest Summer Research Program Symposium

August 6, 2015
Harvard Forest Fisher Museum
Petersham, Massachusetts

VE RI TAS
HARVARD FOREST

Photographs by Andrew McDevitt, Jenny Hobson
and 2015 Summer Program Participants

INTRODUCTION TO THE HARVARD FOREST

Since its establishment in 1907, the Harvard Forest has served as Harvard University's outdoor classroom and laboratory focused on forest biology and ecology. Through the years, researchers at the Harvard Forest have concentrated on forest management, the development of forest site concepts, the biology of trees, plant ecology, soil processes, forest economics, landscape history, conservation biology, and ecosystem dynamics.

Today, this legacy is continued by faculty, staff, and students who seek to understand historical and modern changes in the forests of New England and beyond. Their research has informed conservation and management as well as enhanced appreciation of forest ecosystems and their histories. This activity is epitomized by the Harvard Forest Long Term Ecological Research (HF LTER) program, which was established in 1988 with funding from the National Science Foundation (NSF).

Physically, the Harvard Forest is comprised of approximately 3,750 acres of land in the north-central Massachusetts town of Petersham and surrounding areas. These acres include mixed hardwood and conifer forests, ponds, streams, extensive spruce and maple swamps, fields, and diverse plantations. Additional land holdings include the 20-acre Pisgah Forest in southwestern New Hampshire (located in the Pisgah State Park), which had been a 300 year-old forest of white pine and hemlock when it was blown down in the 1938 Hurricane; the 100-acre Matthews Plantation in Hamilton, Massachusetts, which is largely comprised of plantations and upland forest; and the 90-acre Tall Timbers Forest in Royalston, Massachusetts.

In Petersham, a complex of buildings that includes Shaler Hall, the Fisher Museum, and the John G. Torrey Laboratories provide office and library space, laboratory and greenhouse facilities, and a lecture room for seminars and conferences. Ten colonial-style houses provide accommodations for staff, visiting researchers, and students. Extensive records, including long-term data sets, historical information, original field notes, maps, photographic collections, and electronic data are maintained in the Harvard Forest Archives.

Administratively, the Harvard Forest is a department of the Faculty of Arts and Sciences (FAS) of Harvard University. Faculty associated with the Forest offer courses through the Department of Organismic and Evolutionary Biology (OEB), the Harvard Kennedy School (HKS), and the Freshman Seminar Program. Close association is also maintained with Harvard University's Department of Earth and Planetary Sciences (EPS), School of Engineering and Applied Science (SEAS), School of Public Health (SPH), and Graduate School of Design (GSD). The Harvard Forest's affiliations outside of Harvard University include close ties with the University of Massachusetts departments of Biology, Natural Resource Conservation, and Computer Science; the Marine Biological Laboratory's Ecosystems Center; and the University of New Hampshire's Complex Systems Research Center.

The staff and visiting faculty work collaboratively to achieve the research, educational, and management objectives of the Harvard Forest. A management group meets monthly to discuss current activities and to plan future programs. Regular meetings with the HF-LTER science team, weekly research seminars and lab discussions, and an annual ecology symposium provide for an infusion of outside perspectives. The four-member Facilities Crew undertakes forest management and physical plant activities.

ABOUT THE 2015 SUMMER RESEARCH PROGRAM IN ECOLOGY

The 2015 Harvard Forest Summer Student Research program, directed by Aaron Ellison, with assistance from Manisha Patel (coordinator) and Andrew McDevitt (proctor), attracted a diverse group of students to receive training in scientific investigations and experience in long-term ecological research. All students worked closely with mentors on various research projects from field and laboratory experiments to computer based software and hardware development. The program included weekly seminars from scientists, a career panel, and a field excursion on land-use history. The summer included an annual trip to the Harvard Museum of Natural History in Cambridge, MA, for a tour of the collections. The Harvard Forest Summer Research Program in Ecology culminates in the Student Research Symposium held on August 6th, 2015, where students present their research findings to an audience of scientists, peers, and family.

2015 Summer Program Students

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HARVARD FOREST

2015 SUMMER PROGRAM SEMINARS AND WORKSHOPS

June: 4 Sessions	Ecological analytics with R — *Matt Lau, Harvard Forest*
Mon., June 1	Science Check-in — *Manisha Patel, Harvard Forest*
Thurs., June 4	Forest Walk – *David Foster, Harvard Forest*
Mon., June 8	Talking Science with the Public (part 1) — *Clarisse Hart, Harvard Forest & Marissa Weiss, Science Policy Exchange*
Wed., June 10	Talking Science with the Public (part 2) — *Clarisse Hart, Harvard Forest & Marissa Weiss, Science Policy Exchange*
Wed., June 17	Connecting science and advocacy: Using the decline of whitebark pine as a case study — *Diana Tomback, University of Colorado & Harvard Forest Bullard Fellow*
Wed., June 24	Patterns in the diversity of epiphytic lichens — *Hannah Buckley, Lincoln University (New Zealand) & Harvard Forest Bullard Fellow*
Wed., July 1	The PEcAn Project: Putting ecosystem model-data fusion in your pocket — *Michael Dietze, Boston University*
Wed., July 8	Environmental Stueardship and Sustainable Forestry Practices in Bhutan — *Kinley Tshering, Columbia University*
Wed., July 15	Scientific Presentation & Poster Workshop — *Aaron Ellison, Harvard Forest*
Wed., July 22	Nature Sketching — *Elizabeth Farnsworth, New England Wild Flower Society*
Mon., July 27	Career Panel — *Martha Lyman, Natural Resource Conservation Professional & Harvard Forest Bullard Fellow; Robert Clark, Petersham Conservation Commission and Open Space & Recreation Committee; Tamara Hillman, National Ecological Observatory Network (NEON)*

FUNDING FOR THE 2015 SUMMER RESEARCH PROGRAM IN ECOLOGY

The Harvard Forest Summer Research Program in Ecology in 2015 was supported by the following organizations:

National Science Foundation

REU Site: A Forest full of Big Data: the Harvard Forest Summer Research Program in Ecology 2015-2019 (DBI-1459519)

Collaborative Research: Interacting influences of climate, land use, and other disturbances on regime shifts in forest ecosystems: Holocene dynamics in the northeastern US (DEB-1146207)

Collaborative Research: forecasting and Forestalling Tipping Points in an Aquatic Ecosystem (DEB-1144056)

Collaborative Research: The climate cascade: functional and evolutionary consequences of climatic change on species, trait, and genetic diversity in a temperate ant community (DEB-1136646)

FSML: Walk-up towers for research, education, communication, and outreach at the Harvard Forest (REU Supplement to DBI-1224437)

HFR LTER V: New Science, Synthesis, and Strategic Vision for Society (DEB-1237491)

SI2-SSI: Collaborative Research: Bringing End-to-End Provenance to Scientists (ACI-1450277)

Mount Holyoke College

Miller Worley Center for the Environment Summer Leadership Fellowship

Bryn Mawr College

LILAC Summer Internship Fund

Harvard University

Department of Organismic and Evolutionary Biology

G. Peabody "Peabo" Gardner Memorial Fund

Faculty of Arts and Sciences

23rd ANNUAL HARVARD FOREST SUMMER PROGRAM SYMPOSIUM

THURSDAY, AUGUST 6th FISHER MUSEUM

Aaron Ellison		Welcome

9:30 A.M. Session I: Computational Ecology

Marios Dardas	College of the Holy Cross	Searching data provenance created in the R scripting environment
Katerina Poulos	Mount Holyoke College	Incorporating data analysis workflow into data provenance to increase accessibility
Nathan Justice	Tufts University	EcoApps: A tool for exploring ecosystem dynamics, tipping points, and early warning signals
Tempest McCabe	Bryn Mawr College	When a tree falls in a forest, do ants care? A look at ant community diversity in response to foundation species loss in two forest systems

~ Break ~

10:45 A.M. Session II: The World of Ants

Roxanne Hoorn	Eckerd College	Population density and biodiversity in ant species of the Harvard Forest
Lauren Raiza	Fullerton College	Will you be my neighbor? Community distribution of Harvard Forest ants
Megan Brown	Unity College	The determinants that limit the northern range of common woodland ants
Jordan Zitnay	Unity College	Selective forces that shape physiological tolerance

~ Lunch ~

23rd ANNUAL HARVARD FOREST SUMMER PROGRAM SYMPOSIUM

THURSDAY, AUGUST 6th FISHER MUSEUM

1:00 P.M. Session III: Forests Through Time

Megan Shadley	Mount Holyoke College	Long-term history of fire in Southern New England
Olutoyin Demuren	Harvard University	Morticulture: Exploring wood after death
Katrina Fernald	Wheaton College (MA)	Understory plant community structure and diversity on hurricane tip-up mounds
Mayra Rodriguez-González	University of Puerto Rico — Bayamon	Ecosystem services and hotspot distribution under four different land-use scenarios in Massachusetts, USA

~ Break ~

2:15 P.M. Session IV: Plant Traits

Brittany Cavazos	Rice University	Functional trait diversity in an agricultural setting
Harry Stone	Harvard University	Trees pushed to their limits: How range and climactic data can be a proxy for functional trait variability and determine species at risk.
Julia Fisher	Bates College	Red maple (*Acer rubrum*) and red oak (*Quercus rubra*) exhibit spatial and temporal variation in vulnerability of xylem vessels to cavitation
Natalie Gonzalez	Fullerton College	Understanding the interactive effects of invasive species and climate change on early *Acer rubrum* development
Marissa Saenger	Harvard University	Isoprene and other biogenic volatile organic compounds: Sources, sinks, and mechanisms for plant uptake and emission at the Harvard Forest

~ Break ~

3:45 P.M. Session V: Soil Dynamics

Alana Thurston	Haverford College	The effects of soil warming on relative phosphorus availability and mycorrhizal communities
Josia DeChiara	Hampshire College	Metatranscriptomic analysis of warmed forest soils suggests divergence of community biogeochemical functions over time
Forrest Lewis	Harvard University	Bounding error for total carbon stock estimates in Harvard Forest organic soil

4:30 P.M. Ticks

Aaron Ellison		Tick Study

Megan Brown

Unity College

Mentors: Amy Arnett and Aaron Ellison

Group Project: How far will they go? Ant foraging distances in New England forests as the climate warms

The determinants that limit the northern range of common woodland ants

Aphaenogaster picea reaches the northern limits of its distribution in Maine. The causes for the *A. picea* not found above the 45 degrees N are unknown. Abiotic factors such as climate may limit their ability to move into suitable habitat. In order to determine whether climate influences their range, measures of distribution and abundance were associated with their physiological traits and local environmental conditions. Distribution and abundance were measured by sampling ant colonies in a 50 mile wide transect along 45 degrees N latitude across Maine. In total, 38 plots were sampled, all evenly distributed above and below 45N. 18 *A. picea* colonies were collected and reared under common garden and subjected to hot and cold treatments to determine their physiological limits. There was no relationship between heat tolerance (CT_{max}) and any climatic factors such as mean annual temperature, seasonality, and temperature max. For cold tolerance, we predict that lower thermal limits (CT_{min}) will most likely have a relationship with the distribution and mean annual temperature of *A. picea*. Climate, mainly temperature, acts as a selective force on cold tolerance but not heat tolerance. Climate may limit the colonization of *A. picea* north of 45 degrees N latitude.

Brittany Cavazos

Rice University

Mentors: Dan Flynn and Martha Hoopes

Group Project: Functional trait diversity over an agricultural intensification gradient

Functional trait diversity in an agricultural setting

In the last century, New England has become widely reforested. While these forests provide important services, they are encroaching on open areas crucial not only for agricultural use, but also for the conservation of species unique to open habitats. This project sought to determine if the preservation of open land can benefit both conservation and current agricultural practices using plant community data and grazing treatment with dairy cows. The study site was located at the Harvard Farm in Petersham, Massachusetts. Low-intensity grazing, high-intensity grazing, and control treatments were established over three representative vegetation types. In 27 10x10 meter plots, each with three 1x1 meter subplots, community compositions were recorded before and after the grazing treatment using percent coverage. Plant trait data were also collected, including leaf area, height, leaf angle, SLA, leaf dry matter content, and CN ratios. Functional diversity was used to quantify the range of ecosystem services provided within a community. Initial data indicated functional diversity is strongly driven by vegetation type. Over 100 species were identified and species present within a plot ranged from 5 to 35, highly depending on vegetation type. An overall shift in community composition and functional diversity occurred between the primary and secondary census and functional diversity decreased in the grazing treatment. Further monitoring is needed to conclude agricultural practices can be sustainable over a long period of time. Surveying other taxa in the farm is also crucial to understanding how the ecosystem and services provided are changing over time.

Marios Dardas
College of the Holy Cross
Mentors: Emery Boose and Barbara Learner
Group Project: Data Provenance in R

Searching data provenance created in the R scripting environment

Ensuring that data analysis leads to accurate and reproducible results is critical to scientific progress. As scientists explore increasingly sophisticated issues, they often utilize large data sets and complex models for handling the data. The data provenance, the processes performed to achieve reported results, has become increasingly complex, presenting a challenge to establish the authenticity behind scientific results. Scientists can use RDataTracker, an R library to collect provenance from executing R scripts, to create a Data Derivation Graph (DDG), a structured record of the provenance. DDG Explorer, a program that improves accessibility to DDG, assists with assessing the data provenance. Although the DDG displays this information in an organized fashion, it can be difficult to find specific information within the DDG efficiently – especially within DDG containing hundreds or thousands of nodes. To ensure a quick and intuitive experience with finding data, I focused on creating search capabilities for the DDG. The current search extracts information from the DDG and structures it so that information can be queried by the type of data and associated text information. The interface allows users to enter a search which returns a list of search results. Once the user selects a result the node is displayed. Future updates will incorporate searching within the DDG Explorer's database (implemented with APACHE JENA) by incorporating the SPARQL querying language in addition to an advanced search design to assist with discovering relationships between nodes. Search will assist scientists with debugging programs in addition to quick traversal of the DDG.

Josia DeChiara

Hampshire College

Mentors: Lauren Alteio, William Rodriguez and Jeffrey Blanchard

Group Project: Global warming impacts on soil carbon, nitrogen, and microbiomes

Metatranscriptomic analysis of warmed forest soils suggests divergence of community biogeochemical functions over time

The soil has been shown to be one of the largest carbon stores, of which as much as 50-70% is stored by roots or root-associated microorganisms. As the global temperature continues to rise, the relationship between temperature and microbial carbon cycling is ever pertinent. At the Harvard Forest in Petersham, MA, three experimental warming plots have simulated climate change since 1991, 2003, and 2006 by heating the soil to 5º C above the ambient temperature using underground heating cables. An initial increase in respiration and nitrogen mineralization yielded higher growth rates in plants. As the experiment progressed, plant growth stagnated, hypothetically due a different limiting nutrient. Through measurements of phosphorus content in green and dead leaves, it was observed that phosphorus was being reabsorbed by trees at a higher rate in the heated plots. This led to the hypothesis that phosphorus was stoichiometrically limiting the amount of usable carbon and nitrogen. Phosphorus is found in organisms in phospholipid bilayer, nucleic acids, and adenosine triphosphate, making it an essential biological element. In this study, the role of phosphorus metabolism was examined through analysis of metatranscriptomic data. Nucleic acids were extracted from soils, sequenced, and annotated to determine biological functions. The Mann-Whitney-Wilcoxon test was used to determine genes whose abundance changed with the treatment. These analyses revealed: (1) transcript abundance diverges as heating time increases; (2) changes in gene abundance are evident in in phosphorus and other biogeochemical cycles; and (3) indicator genes for specific metabolic pathways.

Olutoyin Demuren

Harvard University

Mentors: Audrey Barker Plotkin and Anthony D'Amato

Group Project: Long-term forest dynamics following natural or simulated hurricane disturbance

Morticulture: Exploring wood after death

Coarse woody debris (CWD) serves an important purpose in forest ecosystems by altering resource access by organisms and acting as a carbon pool. The Harvard Forest simulated pulldown experiment's massive pulse of such wood provides a valuable opportunity to assess CWD sampling methods. Two methods are compared in this study. The line transect method allows rapid measurement of a large area, and involves measuring the diameters of CWD pieces that intersect random sample transects placed in the pulldown and control plots. In the complete census method, diameter and length measurements of individual downed trees are collected from each entire sample plot. Data collected in 2010 and 2015 were used.

CWD sampling methods gave differing volume results, particularly in the pulldown. The line-transect method gave a higher volume than the tree census method in 2010, but a lower volume in 2015. In contrast, the line-transect method provided a consistently lower volume estimate in the control plot. Volume decreased in the pulldown from 2010-2015, regardless of measurement method. The size distributions of the CWD pieces were compared using Kolmogrov-Smirnov tests. The size distribution of the pulldown data varied significantly between the two methods, whereas the diameter distributions in the control did not. Fewer transects are sampled in the pulldown than in the control, and there is greater variation in volume distribution in the pulldown, which may explain these results. In conclusion, both methods can be used to attain a full picture of dead wood in the forest.

Katrina Fernald

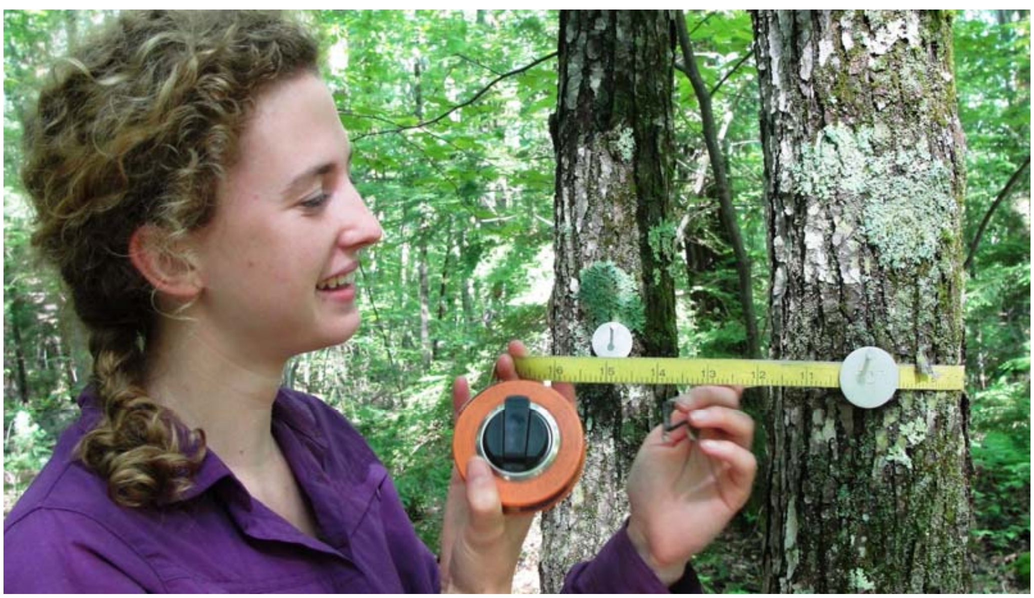
Wheaton College (MA)

Mentors: Audrey Barker Plotkin and Anthony D'Amato

Group Project: Long-term forest dynamics following natural or simulated hurricane disturbance

Understory plant community structure and diversity on hurricane tip-up mounds

Understory plants compose a majority of the vascular plant species in New England hardwood forests. Tree fall gaps and the resources they provide are one major driver in controlling the distribution microenvironments for the understory plant community. Wind events, such as hurricanes, also create tip-up mounds, which alter the topography of the forest floor and create microenvironments for understory plants. This study aims to determine whether the tip-up complexes formed by windthrown trees add to the diversity of understory microenvironments. In particular, it focuses on the species and density of the understory plants on tip-ups. The understory plants shorter than 1 m were sampled on mounds and the adjacent undisturbed forest floor microsite. In preliminary results, the two microsites have a similar number of species, but the average species richness and total plant cover on the mounds is greater than the undisturbed forest floor by p-values of .00011 and 4.6e-7, respectively. These results suggest that mounds provide a more productive and diverse habitat for understory plants. The positive role of tip-up mounds in the forest should be taken into account during post-storm salvage logging operations, which often destroy these important structural changes. Hurricanes are predicted to increase in frequency and severity with climate change. As such, understanding how these events affect our forests can help us prepare anticipate the influence of these events on understory plant community structure and diversity.



Julia Fisher

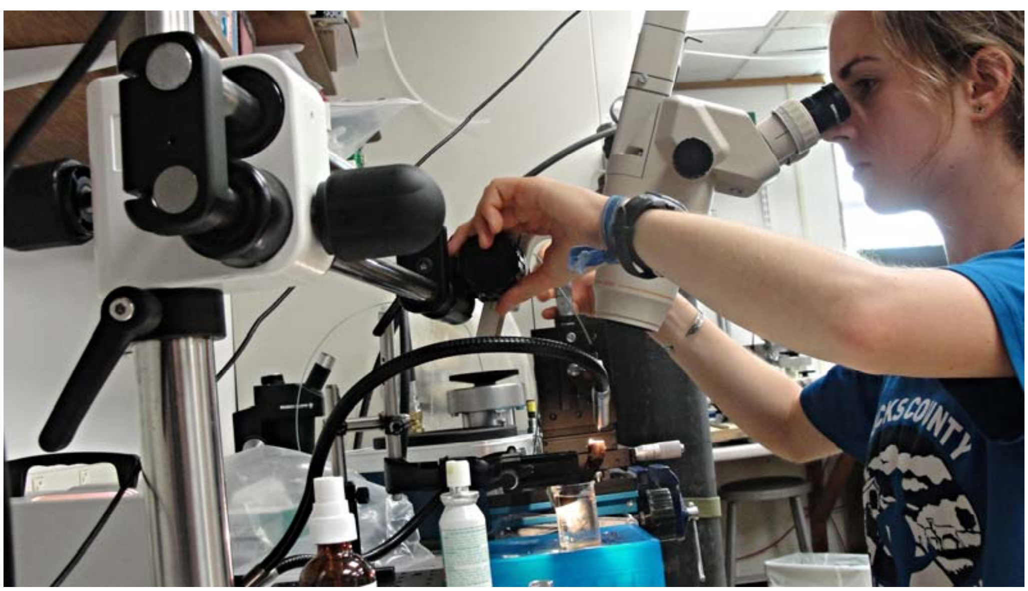
Bates College

Mentors: Craig Brodersen and Brett Huggett

Group Project: Structure and function of New England forest trees: Predicting future forest composition by looking back in time

Red maple (*Acer rubrum*) and red oak (*Quercus rubra*) exhibit spatial and temporal variation in vulnerability of xylem vessels to cavitation

Vulnerability to cavitation was evaluated along the root to leaf pathway in two common hardwood species, red maple (*Acer rubrum*) and red oak (*Quercus rubra*), at the Prospect Hill tract of Harvard Forest in Petersham, Massachusetts, USA. Air seeding pressure analysis was completed on root, trunk, multi-year stem, current-year stem, and petiole tissue of saplings and mature trees of both species. Current year (2015) xylem vessels were measured in all tissue types, and past year (2014) vessels were also measured in multi-year and trunk tissue. There were no differences in air seeding pressures between saplings and mature trees in either species. While *Q. rubra* exhibited only a slightly higher resistance to cavitation in trunk than in petiole tissue, *A. rubrum* exhibited higher resistance to cavitation in trunk and multi-year tissue than in petiole and current-year tissue. *A. rubrum* xylem vessels in current year growth ring were also more resistant to cavitation than vessels from the past year's growth rings. There was, however, no difference in air seeding pressure between growth rings in *Q. rubra*. These data suggest that, although diffuse-porous *A. rubrum* may better adapted to resist cavitation than ring-porous *Q. rubra*, soft petiole tissue in both species may act as dispensable fuses to cavitation. As the threat of cavitation will increase with the predicted increase in drought frequency and intensity, these data have important implications for future timber management plans and conservation strategies.



Natalie Gonzalez

Fullerton College

Mentors: Julia Wheeler, Jennifer Albertine, Dustin Haines and Kristina Stinson

Group Project: Mediating biological invasion in a global change context

Understanding the interactive effects of invasive species and climate change on early *Acer rubrum* development

Climate change and non-native plant invasions can strongly impact native plants. However, climate change and species invasion may interact in complex ways, which could affect native species responses. *Acer rubrum* (red maple) is a common tree species in the northeastern United States where *A. petiolata* is invading and climate regimes are shifting. For this reason, understanding the possible long-term effects of species invasion and climate change on *A. rubrum*, particularly in early seedlings, is critical for predicting how recruitment may change over time. Our objectives were to examine how the interaction of *A. petiolata* invasion and warming impacted germination, survival, phenology, and growth responses of *A. rubrum* seedlings. We planted *A. rubrum* in 160 six-inch pots under 4 different treatment types (Control, heated, *A. petiolata* extract, and heated with *A. petiolata*) and monitored the seedlings for 8 weeks. Findings for this ongoing experiment suggest that none of the treatments significantly influenced the day of onset of germination. Heating resulted in lower total germination and fewer surviving germinants, but was associated with earlier leaf development and higher leaf counts in later growth. Plants on *A. petiolata* addition treatments demonstrated higher total germination and more surviving seedlings. Our results suggest that *A. petiolata* invasion has no detrimental effect on the early development of *A. rubrum* and heating has later growth benefits. Early stage *A. rubrum* performance thus may not suffer under mild to moderate *A. petiolata* invasion, and warming may lead to a longer growing season and increased growth.

Roxanne Hoorn
Eckerd College
Mentor: Aaron Ellison
Group Project: How far will they go? Ant foraging distances in New England forests as the climate warms

Population density and biodiversity in ant species of the Harvard Forest

Ants play an instrumental part in the forests of New England by aerating the soil and promoting habitat biodiversity. These essential services are not carried out by one genus alone. Rather, it takes a collection of colonies of various species functioning together to sustain a healthy forest. In order to deepen our understanding of the variety and distribution of ant species and their contribution to the local ecosystem, I examined the population density and biodiversity of ant species in the secondary growth deciduous forest of Harvard Forest in Central Massachusetts. To do this, I surveyed ants in five thirty -six square meter plots, and identified all colonies were according to species and habitat type. Colonies were mapped to illustrate their relation to one another within the area of study. The mapping and analysis of these plots showed the presence of four genera and six main species, among which their prevalence varied greatly. *Lasius nearticus* was found most commonly with a population density of 0.51 colonies of per square meter; *Apheanagaster picea* was less than half as frequent at a density of 0.23/m^2; *Lasius umbratus* and *Myrmica punctiventris* were both present at a density of 0.4/m^2; with very few occurrences of *Lasius alienus* at 0.02/m^2 and *Formica neogagates* at 0.01/m^2. These findings suggest that there is a combination of factors specific to individual specie preferences, including habitat type and availability, which shape the population density and biodiversity of ants present on the forest floor.

Nathan Justice

Tufts University

Mentors: Matthew Lau and Aaron Ellison

Project: Modeling tipping points and regime shifts in ecological systems

EcoApps: A tool for exploring ecosystem dynamics, tipping points, and early warning signals

To facilitate the investigation of ecosystem tipping points across the scientific community, this project's goal is to lead the development of a computational tool that will allow researchers, regardless of their familiarity with formal programming languages, the ability to simulate ecosystem dynamics and perform tipping point and early warning signal analyses. Ostensibly stable ecosystems are sometimes susceptible to abrupt and drastic changes from one state to another. These rapid state changes exhibit tipping points (sometimes referred to as breakpoints or changepoints), which represent a threshold for a change in the dynamics demonstrated by the ecosystem's state variables. The complexity of ecosystem state changes is compounded by the knowledge that alternative states are often not transient. Generally, humans and other wildlife are accustomed to a preferable ecosystem state, and tipping points do not provide sufficient opportunity for adaptation. Unexpected tipping points are increasingly more likely to occur as human impacts continue to affect and alter ecosystem dynamics across the biosphere. Mounting ecological research suggests tipping points can be simulated with mathematical and statistical models. In addition, simulations of these models have the potential to illuminate early warning signals, which are probable indicators that proceed an imminent tipping point. The product of this project, EcoApps, is a series of web applications implemented using the Shiny framework in R. Each application simulates a distinct ecosystem model. Users are able to explore the model by manipulating parameters and perform tipping point an early warning signal analyses on the simulation's components (observed data, trend, periodicity, and residuals).

Forest Lewis

Harvard University

Mentors: Evan Goldman and J. William Munger

Project: Dynamics of forest carbon on annual to decadal times

Bounding error for total carbon stock estimates in Harvard Forest organic soil

The terrestrial biosphere serves a fundamental role in the global carbon cycle by releasing and absorbing greenhouse gases. At the Harvard Forest, a deciduous forest in Central Massachusetts, biometric measurements have quantified above-ground organic carbon mass, but soil carbon has been less studied. In June-July 2015, I randomly selected 7 of 34 biometric plots from the footprint of the Environmental Measurement Station (EMS) Tower based on tree species variability to sample for soil organic matter (SOM). The cores, which were paired with samples from the 2014 summer survey to minimize spatial variability, were dried, sieved, root picked, ground, and ashed to determine SOM. The organic layer is defined as greater than 40% SOM and is traditionally isolated by separating cores at the point of color and textural change that indicates the mineral layer. Due to difficulty in delineating the organic and mineral layers, previous studies appear to underestimate the total soil carbon stock at the Harvard Forest. The 2014 summer survey estimated 37.36 MgC/ha in the organic layer, but my collocated measurements found 39.752 ± 1.051 MgC/ha. Using updated methods that allow for a more precise delineation as well as upper and lower bounds, changes over 1.051 MgC/ha can be detected on yearly and decadal time scales. By repeating this more precise way of constraining total carbon values, we can ascertain interannual variability in the organic layer carbon stock, which could shed light into the global carbon budget.

Tempest McCabe

Bryn Mawr College

Mentors: Sydne Record and Aaron Ellison

Project: Foundation tree species affects on arthropod communities

When a tree falls in a forest, do ants care? A look at ant community diversity in response to foundation species loss in two forest systems

Eastern hemlock and the oak genus are foundational trees that are under threat from hemlock woolly adelgid (HWA) and sudden oak death, respectively. This experiment looks at the response of ant community composition to simulated impacts of pests and pathogens in the Harvard Forest Hemlock Removal Experiment (HF-HeRE) in Massachusetts and the Future of Oak Forests experiment at Black Rock Forest (BRF) in New York. The HF-HeRE consists of hardwood and hemlock controls, simulated adelgid infestation (hemlocks girdled), and salvage logging (removal of hemlock and merchantable hardwoods) plots. At BRF four treatments investigate effects of oak loss: all oaks girdled, 50% of oaks girdled, all non-oaks girdled, and a control (oaks and non-oaks were unmanipulated). At HF ants were sampled from 25 pitfall traps every year from 2003-2015, and at BRF ants were hand sampled during five years between 2006-2015. A non-parametric multivariate Analysis of Variance (npMANOVA) found significant effects of year, treatment, plot nested within treatment, and treatment year×treatment interaction. Non-metric multidimensional scaling (NMDS) plots of HF-HeRE treatments over time suggest that girdled and logged plots became more similar to hardwood control three years post-treatment and that hemlock control plots became more similar to hardwood control plots 6-8 years post-treatment and after the infestation of HWA to the forest In 2010. In contrast, an npMANOVA for BRF did not reveal any significant effects of treatment, year, or their interaction. These results suggest ant communities may be more resilient to the loss of oaks than to the loss of hemlocks.

Katerina Poulos

Mount Holyoke College

Mentors: Emery Boose and Barbara Lerner

Group Project: Data Provenance in R

Incorporating data analysis workflow into data provenance to increase accessibility

Scientific progress requires the validation, authentication, and reproduction of results to uphold the quality of scientific research. One technique to make large datasets and complex data analyses more intelligible is to capture the data provenance, or the history of a digital object. The current tools developed by the Harvard Forest team to capture and analyze provenance are RDataTracker and DDGExplorer, respectively. These tools create and use a Data Derivation Graph (DDG), a metadata structure that captures data provenance. However, these DDGs may be difficult to comprehend for many R scripts as comprehensibility of a DDG may be inversely proportional to the size and complexity of the script. The objective of this project is to make provenance shown by the DDG more intelligible by breaking it down into multiple sections that reflect typical data analysis workflow. This automated system takes advantage of a common workflow of an R script developed by analyzing various R scripts from the Harvard Forest community. The current interpretation of the typical data analysis workflow was identified and consists of: initialization, data preparation, data analysis, plotting, and output. Building upon existing tools from RDataTracker, my program will provide a higher abstraction to R scripts with little to no user intervention by labelling the portions of the DDG that correspond to these different data analysis activities. By compartmentalizing provenance into comprehensible bits using lingo known by all scientists, a potentially large and complex DDG will be collapsed into more readily coherent sections which will increase accessibility.

Lauren Raiza

Fullerton College

Mentor: Aaron Ellison

Group Project: How far will they go? Ant foraging distance in New England forests as the climate warms

Will you be my neighbor? Community distribution of Harvard Forest ants

Ants are complex social creatures that live in a variety of habitats within the Harvard Forest in Central Massachusetts. They occupy trees, soil, and leaf litter and are responsible for breaking down decaying matter, aerating and producing soil, and even dispersing seeds. With all of these jobs to do and places to be, it is no wonder that the different genera and species of ants that occupy the Forest live very different lives. These ants' lives intertwine when competition for habitat or other resources come into play, and these interactions may affect their selection of nesting sites. To examine which species of ants were likely to nest near one another, five thirty-six square meter plots were sampled within the forest to examine spatial distribution of nest sites. By examining spatial relationships between *Aphaenogaster picea, Formica neogagates, Lasius nearcticus, Lasius umbratus, and Myrmica punctiventris* much can be learned about the behavior of these ants and how their distribution can affect forest dynamics. Further investigation of these interspecies relationships may provide insight into nest site and neighbor selection behaviors in relation to competition.

Mayra Rodriquez-Gonzalez

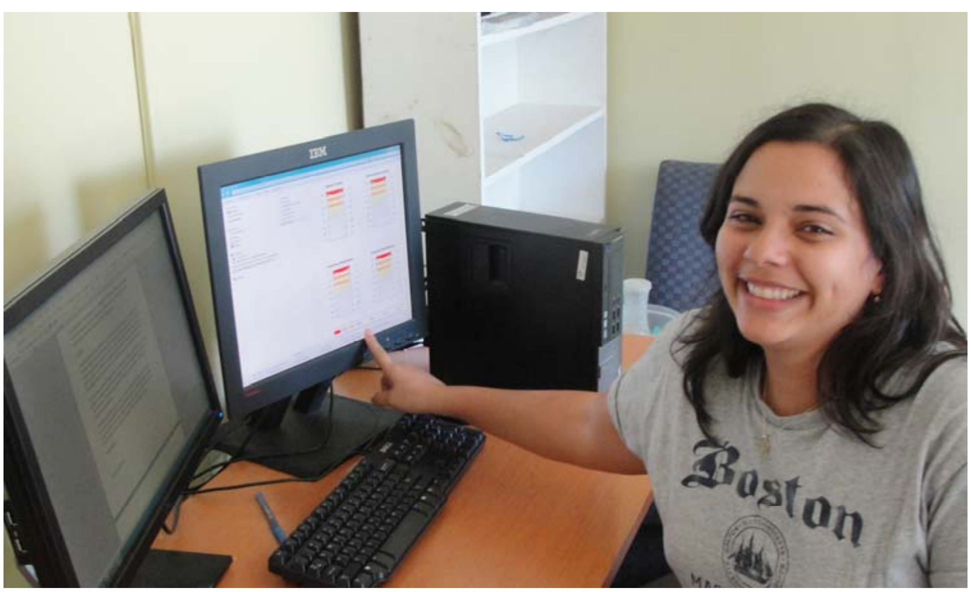
University of Puerto Rico—Bayamon

Mentors: Luca Morreale, Meghan Blumstein, Matthew Duveneck and Jonathan Thompson

Group Project: Land use effects on New England forest composition and structure

Ecosystem services and hotspot distribution under four different land-use scenarios in Massachusetts, USA

Simulating land-use effects on ecosystem services can inform land management and policy decisions. Using four land-use scenarios for the state of Massachusetts, this study maps land-use impacts on the state's capacity to provision ecosystem services over time, and emphasizes changes in the abundance and distribution of service "hotspots," which are areas that provide a high value for multiple services. The scenarios depict alternative trajectories of land-use over the next 50 years, including different rates, intensities, and spatial arrangements of development, harvest, agriculture and conservation. Throughout the simulations, the *Recent Trends* scenario had the least area of hotspots, but those areas were comparatively stable. In contrast, the *Opportunistic Growth* scenario had the greatest loss of high-value areas, while the *Regional Self-Reliance* scenario had the greatest increase in high-value areas. In all scenarios, the area of hotspots increased through time, which reflects the concentration of services on to less area and, in some cases, the expansion of timber and agriculture. We conclude that, in aggregate, land-use decisions produce distinct patterns of ecosystem service provisioning. However, we also note that the estimated effects of land-use on services are strongly affected by the modeling approach. Nonetheless, this type of multi-service, multi-scenario assessment can inform policymakers regarding the potential consequences of land-use and assist them in identifying priority conservation zones.



Marissa Saenger

Harvard University

Mentor: Karena McKinney

Project: Exchange of biogenic volatile organic compounds between the forest and the atmosphere

Isoprene and other biogenic volatile organic compounds: Sources, sinks, and mechanisms for plant uptake and emission at the Harvard Forest

All plants emit biogenic volatile organic compounds (BVOCs), hydrocarbons that interact with atmospheric compounds to form products such as ozone and aerosol particles. Isoprene comprises roughly half of BVOC emissions worldwide, and its reactions affect tropospheric ozone levels, which influences climate and air quality. BVOCs are emitted in varying levels by different plant species: grapes (*vinis vinifera*) are known to lack isoprene emissions, while red maple (*acer rubrum*) and red oak (*quercus rubra*) exhibit low and high isoprene emission levels, respectively. The goals of this project were to determine isoprene and other BVOC emission levels among these species along with photosynthesis and transpiration rates and to determine methods of emission and uptake. The experiments used a protontransferreaction mass spectrometer (PTRMS) to detect levels of isoprene and other BVOCs (including acetone, monoterpenes, acetaldehyde, and oxygenated terpenes), sampled from bag chambers enclosing plant leaves. Each species was tested individually for 24 hours, repeated several times using different leaves or specimens. CO2 and water concentrations, measured simultaneously using a Li840A instrument, were used to calculate transpiration and photosynthesis rates of the enclosed leaves and test for correlations between these processes and BVOC emissions. Stomatal conductance was calculated from transpiration rates and used to assess the role of stomata on BVOC emissions. Findings were consistent with expectations regarding relative isoprene emission levels among the three species. The data collected indicated peaks in most BVOC emissions during daylight hours, along with transpiration and photosynthesis rates, indicating correlation between BVOC emissions and leaf transpiration and photosynthesis.

Megan Shadley

Mount Holyoke College

Mentor: Wyatt Oswald

Project: Using paleoecology to understand long-term forest dynamics in New England

Long-term history of fire in Southern New England

For decades, some ecologists and conservationists have asserted that Native Americans commonly utilized prescribed fire as a method of forest management in New England long before European settlement (Day 1953, Abrams 1992). Accordingly, fire would have been prevalent during peaks in human population in the middle and late Holocene (Munoz et al. 2010), when large numbers of people purposefully burned forests to favor food-producing plants and to facilitate hunting and travel. Alternatively, the effects of changing vegetation and/or climate may have controlled fire by impacting fuel conditions. To date, few lake-sediment charcoal records have been available to test these hypotheses. The influx of charcoal pieces provides a proxy for the relative abundance of fire events, particularly in a localized watershed area. In this study we analyzed charcoal preserved in the sediments of three Massachusetts ponds: Green Pond in Montague, and Jernagen's and Lily ponds on Martha's Vineyard. The two sites on Martha's Vineyard would have had particularly high indigenous populations during the late Holocene. We found that all three sites had low charcoal influx values during intervals of high human populations, suggesting that the human control of fire was less important than previously believed. Continued paleoenvironmental studies of cores from Ware Pond in Marblehead, MA, may yield further insights into the role of climate change in long-term variations in fire activity.

Harry Stone

Harvard University

Mentors: Dan Flynn and Elizabeth Wolkovich

Project: Tree functional traits across climate gradients

Trees pushed to their limits: How range and climactic data can be a proxy for functional trait variability and determine species at risk

Broadleaf temperate forests in the Northeast are an important economic and ecological zone facing an increasing risk due to intensifications in temperature and a shifting climate. While the future impact is not well understood, a latitudinal gradient in the biome could be used to predict temporal changes and how the forest and specific species may respond. The intended goal of this research is to determine how woody deciduous species react differently to being pushed to their climatic limits. Morphological, physiological, and chemical traits were measured of 393 individuals stemming from 38 species. Sampling occurred at the Harvard Forest and the University of Montréal Laurentides field station to create a 3.70 degree latitudinal shift to determine how a harsher climate impacts viability. GIS tools were used to compare the two field sites to the range extents of the studied species. Spatial and temperature-linked distance to end of range predicted functional trait changes and variability on a species to species basis. Trees and shrubs with a larger range were predicted to have more phenotypic plasticity and thus resistant to change across the latitudinal range. Species with a greater northern extent, such as *Betula papyrifera* and *Populus tremuloides*, are buoyed more against the climate shift and their functional trait response is more muted. Results show a decrease in specific leaf area, stem specific density, leaf dry matter content, and percent nitrogen between the Harvard Forest and Quebec highlighting a mainly conservative growth strategy.

Alana Thurston

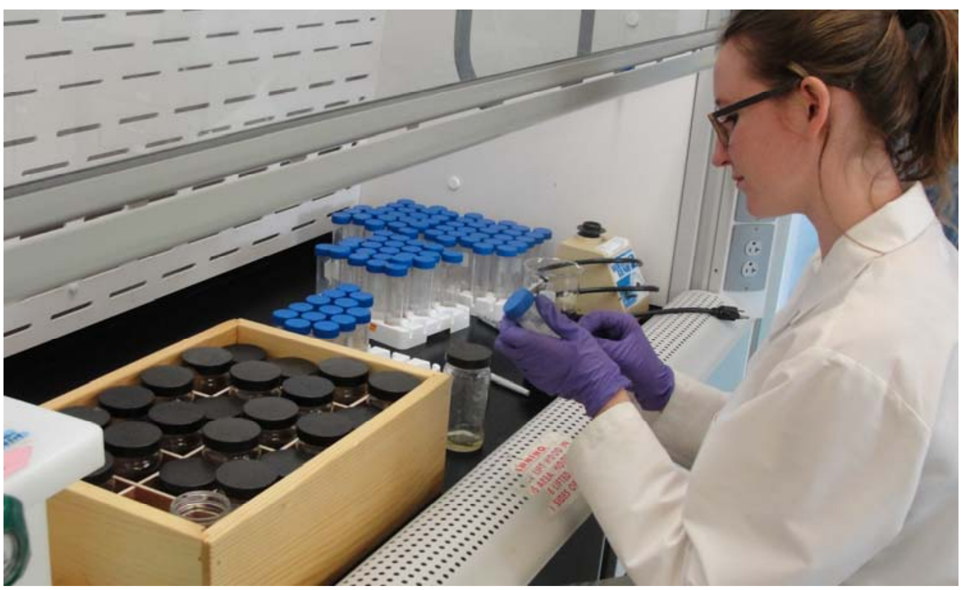
Haverford College

Mentors: Michael Bernard, William Werner and Jerry Melillo

Group Project: Global warming impacts on soil carbon, nitrogen, and microbiomes

The effects of soil warming on relative phosphorus availability and mycorrhizal communities

Soil warming, as an effect of climate change, has the potential to alter soil processes, nutrient availability, and soil community composition. The Barre Woods Soil Warming Experiment was designed to monitor these effects, and in the first decade of the experiment, nitrogen availability increased, leading to accelerated aboveground tree growth. However, in the past two years, woody increment has returned to control rates and phosphorus resorption in leaf tissue has increased, leading us to hypothesize that chronic soil warming has led to progressive phosphorus limitation. We developed two hypotheses that could explain phosphorus limitation – reduced phosphate bioavailability or shifts in mycorrhizal exploration types. We used ion exchange membranes to assess the effect of soil warming on phosphate availability, and found that there were no significant differences between treatments. However, by characterizing 59 ectomycorrhizal morphotypes, we found that there was a significant shift to contact exploration species in the heated plot over both short and long-distance. This indicates that trees in the heated plot might not have as much access to phosphate because they aren't connected to a large hyphal network. Alternatively, the shift in mycorrhizal species could change the enzymes produced in the soil, which would affect the breakdown of organic matter and nutrient availability. We tested the potential enzyme activity of phosphatase – an enzyme produced by fungi to make phosphate ions available – but found that there was no significant difference between treatments.



Jordan Zitnay

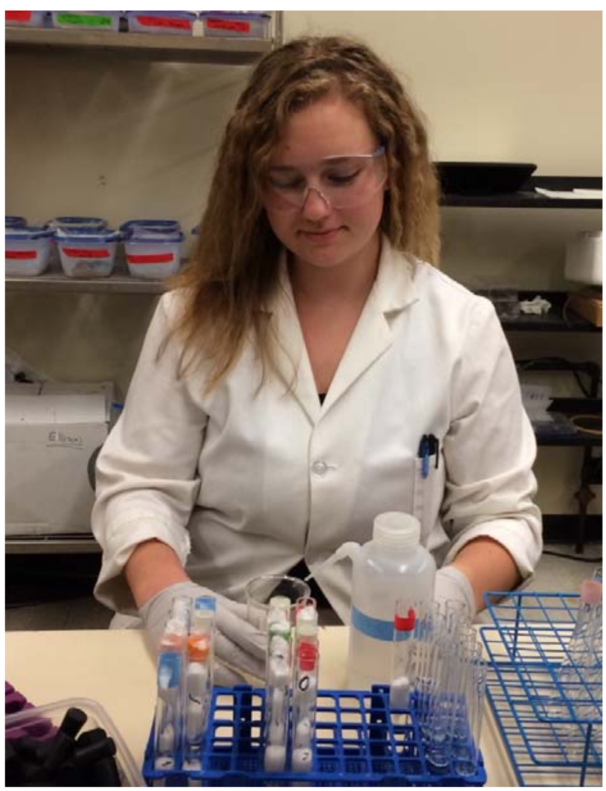
Unity College

Mentors: Amy Arnett and Aaron Ellison

Group Project: How far will they go? Ant foraging distances in New England forests as the climate warms

Selective forces that shape physiological tolerance

Ants occupy a wide variety of environments but their abundance and distribution can be limited by numerous biotic and abiotic factors. In particular, for the common woodland ant (*Aphaenogaster picea)*, the northern edge of its range does not extend past 45°N in Maine despite suitable nesting habitat. Limitations in physiological tolerance for temperature extremes may limit their range expansion. To determine whether climatic variables shape thermal tolerance, we associated measures of hot and cold temperature tolerances for 18 colonies that were collected along the species' northern range under common garden conditions with climatic factors. High temperature tolerance was measured as the loss of motor function during slow ramping temperature treatment (CT_{max}) and cold temperature tolerance was measured as recovery time after exposure to cold shock (CT_{min}). There was no relationship between CTmax and mean annual temperatures for *A. picea* colonies collected at their northern range boundary. However, there was a negative relationship between cold tolerance of ants and mean annual temperature. Temperature acts as a force of selection for cold but not heat tolerance on the populations of a common woodland ant at the northern end of their range.



PERSONNEL AT THE HARVARD FOREST - 2015

Jay Aylward	Research Assistant
Audrey Barker-Plotkin	Site and Research Manager
Daniel Bishop	Research Assistant
Emery Boose	Information Manager
Jeannette Bowlen	Accountant
Laurie Chiasson	Administrative Assistant
Betsy Colburn	Aquatic Ecologist
Elaine Doughty	Research Assistant
Matthew Duveneck	Post-Doc
Edythe Ellin	Director of Administration
Aaron Ellison	Senior Ecologist/Community Ecologist
Kathy Fallon Lambert	Director of Science and Policy Exchange
David Foster	Director of Harvard Forest
Lucas Griffith	Woods Crew
Brian Hall	GIS Specialist
Julie Hall	Assistant Data Manager
Clarisse Hart	Outreach and Development Manager
Jenny Hobson	Secretary
David Kittredge	Forest Policy Analyst
Oscar Lacwasan	Woods Crew
Matthew Lau	Post-Doc
Ronald May	Woods Crew
Roland Meunier	Woods Crew
Alisha Morin	Accounting Assistant
Luca Morreale	Research Assistant
John O'Keefe	Museum Coordinator (Emeritus)
David Orwig	Senior Ecologist/Forest Ecologist
Julie Pallant	Information Technology and Archives Administrator
Manisha Patel	Lab Manager and Summer Program Coordinator
Neil Pederson	Senior Ecologist/Forest Ecologist
Joshua Plisinski	Research Technician
Lisa Richardson	Accounting Assistant
Pep Serra Diaz	Post-Doc
Pamela Snow	Schoolyard Program Coordinator
Jonathan Thompson	Senior Ecologist/Landscape Ecologist
Greta VanScoy	Museum Coordinator
Mark VanScoy	Field Instrument Specialist
Marissa Weiss	Science Policy Exchange Coordinator
John Wisnewski	Woods Crew Supervisor
Peter Yesmentes	Summer Program Assistant Cook
Tim Zima	Summer Program Cook

Harvard University Affiliates

Richard Forman	Graduate School of Design
Noel Michele Holbrook	Organismic and Evolutionary Biology
William Munger	School of Engineering and Applied Sciences
Andrew Richardson	Organismic and Evolutionary Biology
Steven Wofsy	School of Engineering and Applied Sciences
Elizabeth Wolkovich	OEB and Arnold Arboretum

2015 SUMMER RESEARCH PROGRAM STUDENTS

Megan Brown
Unity College

Brittany Cavazos
Rice University

Marios Dardas
College of the Holy Cross

Josia DeChiara
Hampshire College

Olutoyin "Olu" Demuren
Harvard University

Katrina "Katie" Fernald
Wheaton College (MA)

Julia Fisher
Bates College

Natalie Gonzalez
Fullerton College

Roxanne Hoorn
Eckerd College

2015 SUMMER RESEARCH PROGRAM STUDENTS

Nathan Justice
Tufts University

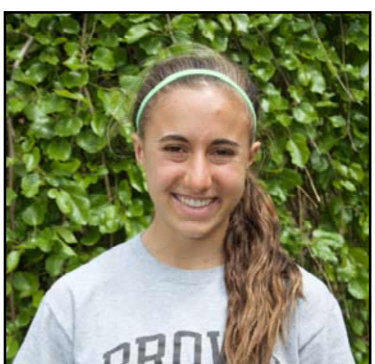
Forrest Lewis
Harvard University

Tempest "Tess" McCabe
Bryn Mawr College

Katerina "Lia" Poulos
Mount Holyoke College

Lauren "Cody" Raiza
Fullerton College

Mayra Rodriquez-Gonzalez
Univ. of Puerto Rico—Bayamon



Marissa Saenger
Harvard University

Megan Shadley
Mount Holyoke College

Harry Stone
Harvard University

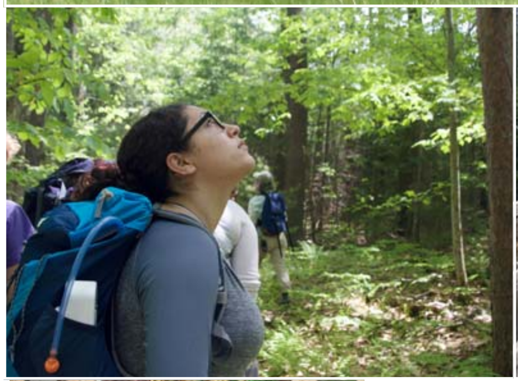
2015 SUMMER RESEARCH PROGRAM STUDENTS

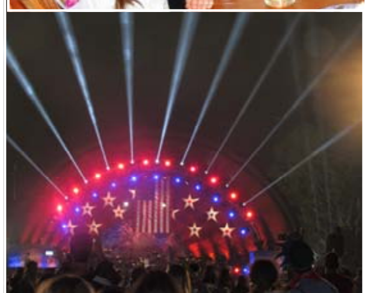
Alana Thurston
Haverford College

Jordan Zitnay
Unity College

2015 SUMMER RESEARCH PROGRAM PROCTOR

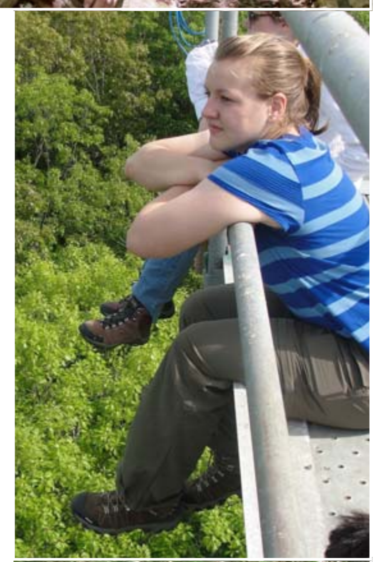
Andrew McDevitt
Illinois State University

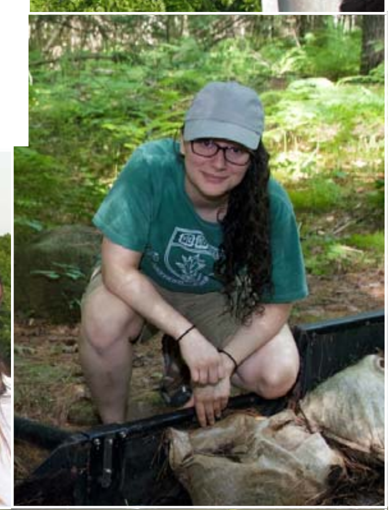


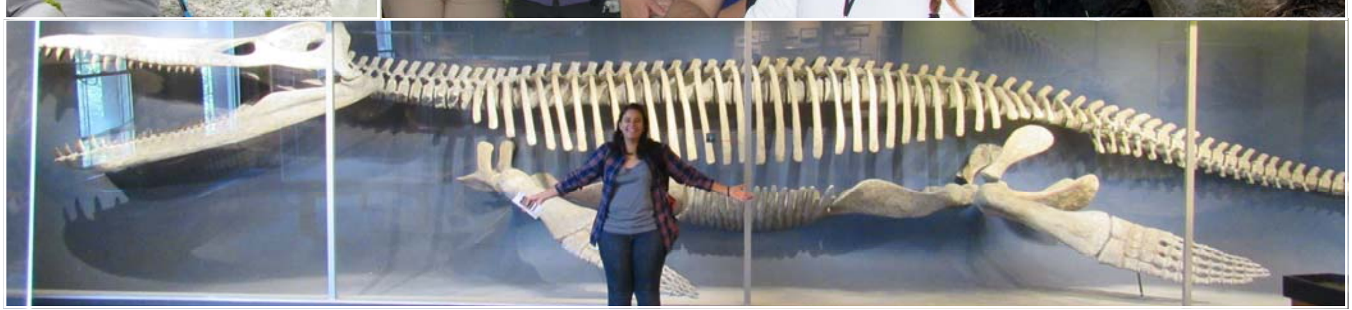


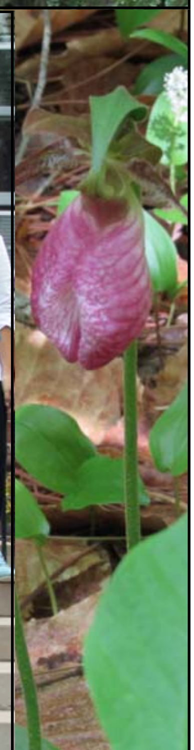
Harvard Forest

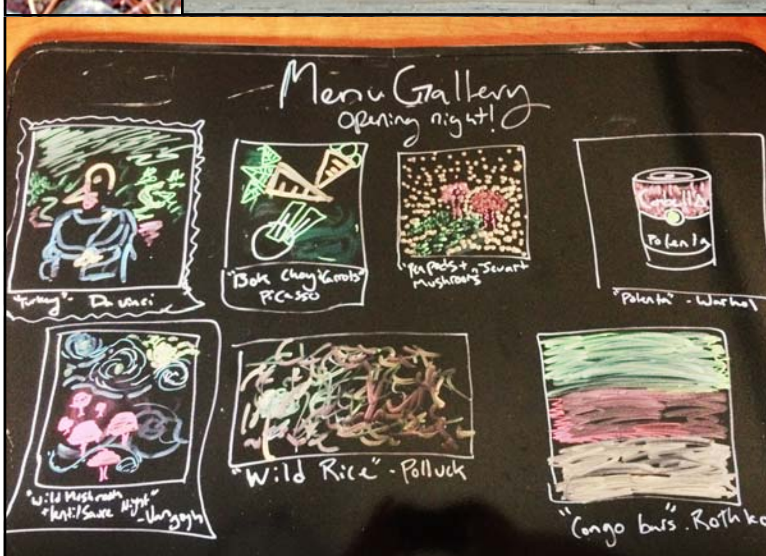
Summer Program 2015










Menu Gallery
opening night!
"Turkey" - Da Vinci
"Bok Choy" "Carrots" Picasso
Polenta
"Polenta" - Warhol
"Wild Rice" - Polluck
"Congo bars". Rothko